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PROGRAM FOR THE

BERKELEY MEETING

UNIVERSITY OF CALIFORNIA,
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MARCH 3, 1928

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BERKELEY MEETING, MARCH 3, 1928

The 150th regular meeting of the American Physical Society will be held at the University of California, Berkeley, California, in room 212 LeConte Hall, on Saturday, March 3.

Titles and abstracts are given in the following pages in order of presentation:

Morning session, 9:30 o'clock, papers 1–15.

Afternoon session, 2 o'clock, papers 16–29.

Other meetings of the current season are as follows:

151. April 20–21, 1928. Washington.

152. June 15, 1928. Pacific Coast Section at Pomona.

153. November 30–December 1, 1928. Minneapolis.

154. New York City. Annual Meeting.

L. B. LOEB,
Local Secretary for the Pacific Coast,
University of California, California.

PROGRAM

1. A relation between the variations with temperature and density of the coefficient of recombination of gas ions. A. M. CRAVATH, University of California.—Different writers generally agree as to the nature of the recombination process, but differ greatly in their final theories because of the neglect of different factors in the developments. By the rigorous application of dimensional analysis and the assumption that the masses of the ions do not change with moderate temperature variation, the following relation connecting the temperature and density variations of α, the coefficient of recombination, is derived:

$$\left(\frac{\partial \ln \alpha}{\partial \ln \rho}\right)_\theta \left\{1.5+\left(\frac{\partial \ln k}{\partial \ln \theta}\right)_\rho\right\}+\left(\frac{\partial \ln \alpha}{\partial \ln \theta}\right)_\rho = -1.5$$

k is the average of the positive and negative ion mobilities, ρ is the gas density, and θ is the absolute temperature. This equation may be used as a test of the physical assumptions, or if these are assumed it may be used to calculate the temperature variation from the more easily measured density variation. Present experimental data are too uncertain to permit a significant test. They give from -1.75 to $+0.25$ as compared to the above value -1.5.

2. Radioactive properties of waters and soils in the southern California region. J. L. BOHN, California Institute of Technology.—This work on the radioactivity of soils and waters was started in connection with the work of Dr. Millikan and Dr.Cameron on cosmic radiation to find the activity in the vicinity of their measurements. The radioactivity of the waters of Lake Arrowhead was found to be not more than 1/200th of that of the reservoirs in Pasadena. Also the radioactivity of the soil where cosmic ray readings were taken was twice that of the soil on the Institute campus. The paper also presents measurements of radioactivity as a function of depth.

3. The systematic variation of the constant A in thermionic emission. LEE A. DUBRIDGE, National Research Fellow, California Institute of Technology.—A recent study of the thermionic emission from Pt (Phys. Rev., Feb. 1928) has shown that changes in the work function b during outgassing are always accompanied by changes in A (of the equation $i = A T^2 e^{-b/T}$) in such a way that log A is a linear function of b. Data obtained by other observers show this same relation for other metals. The slope of the straight line depends on the type of surface studied, being small for coated W (Dushman, Kingdon) and large for liquid surfaces (Goetz, Zeits. f. Physik. **43,** 531(1927)). Dushman's theoretical value of A (60.2 amp/cm^2 deg^2) is observed only when b happens to be about 52,000°K, and nearly all the lines pass near this point. "Abnormal" values of A have usually been attributed (most recently by Bridgman, Phys. Rev. **31,** 90(1928)) to the effect of surface contamination. However for *clean* Pt $b = 73{,}500$ and $A = 14{,}000$ which is 230 times the theoretical value. Whether these results can best be interpreted by the introduction of a factor involving the surface heat of charging as suggested by Bridgman and Langmuir and Tonks, or by the adoption of the more detailed picture of the process developed by Raschevsky seems as yet uncertain.

4. The cataphoresis of small gas bubbles in various organic liquids. KARL DYK, University of California, (Communicated by Leonard B. Loeb).— The cataphoresis of small gas bubbles in water has been explained as the result of a superficial negative charge caused by an electrical double layer at the gas-liquid boundary (Lenard, Ann. der Physik **47,** 492, 1915). Alty (Proc. Roy. Soc. **A112,** 235, 1926) and McTaggart (Phil. Mag. **44,** 386, 1924) conclude the effect is due to ionic impurities. McLaughlin (Proc. Roy. Dub. Soc. **17,** 13, 1922) investigated organic liquids at low fields and detected no charge on gas bubbles. Experiments were undertaken in this laboratory to test this for high fields since it was suspected that, with lower dielectric constant, the double layers would be less highly charged and would require higher fields for detection. Experiments, by McTaggart's method indicated it to be ill suited to such experiments, because of the high expansion coefficients of the liquids. A

new technique has been evolved with the result that the simple behavior observed for water droplets is not observed for organic liquids up to fields of 15,000 volts/cm. Minute bubbles appear to be charged under some circumstances, but change the sign of their charge rapidly in progressing through the field. Polarisation and purification phenomena were also observed in various organic liquids at the high fields used.

5. Mobility of gaseous ions in H_2S–H_2 mixtures. LEONARD B. LOEB AND L. DUSAULT, University of California.—Mobilities of ions in carefully purified H_2S and in H_2S–H_2 mixtures have been measured. The values of mobilities on the ordinary scale of mobilities are 0.588 and 0.572 cm/sec per volt/cm for positive and negative ions respectively; on the new absolute scale they must be multiplied by 1.21. Results obtained at low pressures indicate that the inverse pressure law may not hold accurately for the positive ions, while it does hold for the negative ions. The mobility constant of the former appears slightly *less* than the value at higher pressures. This result for both ions is contrary to the expectations of the ion theory of A. P. Alexeievsky (Phys. Rev. **27,** 811, 1926), which requires an increase of some 10 per cent. In pure samples of H_2S, free electrons were observed in H_2S below 50 mm. This places H_2S between air and O_2 in its power of attaching electrons to form ions. Mobilities of ions in H_2S–H_2 mixtures show that traces of H_2S lower the mobility of both ions well below the values computed from Blanc's law of mixtures. This again indicates clustering.

6. Collector measurements in the positive column of the noble gases. W. UYTERHOEVEN. (Fellow C. R. B. Educational Foundation), California Institute of Technology.—The positive column of the noble gases was studied by using plane collectors of different sizes and materials, and applying Langmuir's theory (Gen. El. Rev. Vol. **27,** 1924). The positive ion currents did not show saturation, nor did the value of the current density computed by means of the measured sheath thickness and the space charge equations agree with the measured current density. The most satisfactory interpretation of these experiments (partly done in the Philips Laboratory, Eindhoven, Holland) seems to be to assume a very large secondary electron emission (50 per cent of the total current, and even more for low accelerating potentials of the collector). As to the cause of this electron emission, the experimental data seem to eliminate the action of the positive ions as a possible explanation. Probably the metastable atoms are responsible for the effect, either by interaction in the positive ion sheath, as suggested to me by Prof. K. T. Compton, or by direct action of the excited atoms on the metal surface (conductive photoelectric effect). Further experiments are under way to test this last explanation, this secondary emission being an important element in the theory of the cathode fall of the glow discharge.

7. Different types of field currents, their laws and the conditions under which they arise. C. C. LAURITSEN AND R. A. MILLIKAN, California Institute of Technology.—Further evidence is herewith presented for the view earlier advanced (Phys. Rev. **27,** 51, 1925) that field-currents originate only in individual "weak spots" on the emitting surface. These weak spots are of two sorts, first those which are entirely undiscernible by mechanical or optical means; second, those resulting from definite surface explosions or "ruptures" which leave behind them craters with jagged edges. The present paper differentiates the characteristics of the field-currents from both types of weak spots. It however presents further proof that all field-currents whether of one sort or the other follow the law recently reported (Proc. Nat. Acad. Sci. Jan. 1928) by us as a result of experimental studies, and simultaneously given a theoretical explanation by Oppenheimer on the basis of wave-mechanics. This paper also presents experimental proof that field-currents are uninfluenced by temperature changes between ordinary and liquid-air-temperatures, as we previously predicted. (Proc. Nat. Acad. Sci. Jan. 1928).

8. Field currents from points. C. F. EYRING, S. MACKEOWN, AND R. A. MILLIKAN, California Institute of Technology.—The laws governing the extraction of electrons from metals in

high vacua by fields, first developed through experiments with crossed wires (Millikan and Shackelford, Phys. Rev. **15**, 239, 1920) then with fine wire cathodes discharging to cylindrical anodes, (Millikan and Eyring, Phys. Rev. **27**, 51, 1926) have been now found to hold throughout for field currents between points and planes. The theory needed for the quantitative determination of the potential gradients at points is here given, and critical gradients then determined experimentally. The generality of the linear relation between log i and the reciprocal of field-strength (Millikan and Lauritsen, Proc. Nat. Acad. Sci., January, 1928) is experimentally established.

9. On the quantum theory of field currents. J. R. OPPENHEIMER (National Research Fellow), California Institute of Technology.—The pulling of electrons out of metals by intense electric fields may be interpreted on the quantum mechanics as the ionization of the metallic atoms by the field. The theory then gives, for the dependence of the field current i (amps) the field strength F (volts) and the work function W (volts)

$$i = 3\times 10^{-6} F^{1/4} W^{5/8} \exp\left\{-10^8 W^{3/2}/F\right\}$$

per surface atom. The form of the resulting characteristic is that found experimentally by Millikan and Lauritsen: $ln\ i = \text{const.}/F$. The experimental values of the constant, derived by the use of a field strength computed from the geometrical dimensions of the wire, gives pW about 0.4 volt. The introduction of the dimensions of the points surrounding the craters on the wire, which are found experimentally to give the current, raises the value of W to about 5 volts, and shows that only a small number of surface atoms take part in the effect.

10. On the theory of the radiometer. PAUL S. EPSTEIN, California Institute of Technology.—The radiometric effect in extremely rarefied gases has been clear to us since Knudsen's extensive work on this subject. But a treatment of the case of comparatively dense gases (mean free path, l, small compared with the linear dimensions of the vane) has been lacking, though the foundations for it were laid as far back as 1879 by Maxwell. The present computations have the purpose of supplying this want; they are carried through for a thin circular disk. If a is the radius and δ the thickness of the disk, and if I is the energy of radiation falling on unit area of its front surface and absorbed in its surface layer, one obtains a formula for the radiometric force which we give here for two limiting cases:

$$K_1 = -\frac{1.70a}{K_a}\frac{pl^2}{T}I, \qquad K_2 = -\frac{2.66}{K_i}\cdot\frac{pl^2}{T}I.$$

K_1 applies to the case for which the thermal conduction of the vane is poor, K_2 when it is good, p,T denote temperature and pressure of the gas, K_a, K_i heat conductivity of the gas and of the material of the vane.

11. The dispersion by hydrogen-like atoms in wave mechanics. BORIS PODOLSKY, California Institute of Technology.—The Schroedinger wave equation for a hydrogen-like atom in the field of a plane electromagnetic wave is solved by a method of expanding the wave function into a series of characteristic functions forming a complete orthogonal set. The result for atomic hydrogen is the following formula: $n^2 - 1 = 2.24\times 10^{-4}(1 + 1.228\times 10^{-10}/\lambda^2 + \cdots)$, where n is the index of refraction and λ the wave-length of the incident light. For the limiting case of electrostatic field, $\lambda = \infty$, this gives the dielectric constant $\epsilon = n^2 = 1 + 2.24\times 10^{-4}$, in agreement with results previously obtained by Van Vleck, Epstein, and Pauling.

12. The fermi statistics applied to electrocapillarity. OSCAR KNEFLER RICE (National Research Fellow), California Institute of Technology.—It is assumed that each atom in mercury is ionized into a positive ion and an electron. Due to the crowded state of the positive ions it is supposed that they cannot move in an electric field, while, following Sommerfeld, the electrons are assumed to act like a completely degenerate gas following the Fermi statistics. The distribution of electrons under an electric field due to a charge on the surface of the metal is discussed, and a relation derived which gives the charge on the surface in terms of the potential

difference between surface and interior. To a first approximation the charge and potential difference are proportional to each other, as if there were a condenser of constant capacity at the surface. The magnitude of the equivalent capacity is such that, when considered in conjunction with the diffuse layer of ions in the solution, electrocapillary curves can be explained.

13. The gravitational field of a body with rotational symmetry in Einstein's theory of gravitation. P. Y. CHOU, California Institute of Technology.—Einstein's set of field equations in vaccuo, $G_{\mu\nu}=0$, is reduced to such a form that simple problems like the sphere (Schwarzschild's solution), the infinite plane and the infinite cylinder can be solved. The fundamental quadratic differential forms for the latter two cases are respectively,

$$ds^2=-[(1+4\pi\sigma z)^{-1}dz^2+d\rho^2+\rho^2d\phi^2]+(1+4\pi\sigma z)dt^2,$$

$$ds^2=-c_4^2\rho^{-2}[(1+4m\log\rho)^{-1}d\rho^2+\rho^2d\phi^2]-dz^2+(1+4m\log\rho)dt^2,$$

where σ is the surface density of matter on the plane, $z=0$; m the linear density of matter on the cylinder, $\rho=$const.; (ρ, z, ϕ), the cylinder coordinates, c_4, an undetermined constant and the velocity of light is unity. Setting $g_{44}=$the Newtonian potential+const., we can get the solution of the general gravitational problem for a body whose mass is distributed symmetrically about an axis provided we can solve

$$2\frac{\partial}{\partial\psi}\left((1-2M\psi)\frac{\partial\gamma}{\partial\psi}\right)+\frac{\partial^2}{\partial\theta^2}e^{\gamma}=0 \qquad (M=\text{mass of the body}).$$

The gravitational field of an oblate spheroidal homoeoid is characterized by

$$ds^2=-\psi^{-4}(1-2M\psi)^{-1}d\psi^2-\psi^{-2}d\xi^2-\psi^{-2}\cos^2\xi d\phi^2+(1-2M\psi)dt^2$$

where $\psi=\kappa^{-1}\cot^{-1}(\sinh\eta)$, $M=$mass of the homoeoid whose equation is $c^2\rho^2+a^2z^2=a^2c^2$, $\kappa^2=a^2-c^2$ and ξ, η are related to the cylindrical coordinates (ρ, z, ϕ) by $\rho+iz=\kappa\cos(\xi+i\eta)$. Analogous expressions for a prolate spheroidal homoeoid are obtainable. The oblateness of the homoeoid causes a slight increase in the advancement of the perihelion of a planet's orbit which was derived from Schwarzschild's solution.

14. Diurnal variation of distribution of the surface charge of the earth around the parallel of 37½° for the year 1927. FERNANDO SANFORD, Stanford University.—That the distribution of the surface charge of the earth is not constant is shown by the existence of earth-currents and the accompanying magnetic variations and by the variations in the electrostatic field of the atmosphere. The fact that all these phenomena show fairly regular diurnal and seasonal changes in both intensity and direction is evidence that they are influenced, if not determined, by the position of the sun relative to the place of observation. The diurnal variation of the surface intensity of the earth's charge at Palo Alto has been almost continuously recorded photographically for the past six years, and recently a new and very sensitive method of recording it has been devised which is free from all possible effects of changes in atmospheric conductivity. It has been found that there is both a solar and lunar diurnal variation and a seasonal variation which is greatest at the equinoxes and least at the solstices. The average diurnal variation for each month of the year is shown by curves, and the average distribution for the year of the variable part of the charge is shown by a Bidlingmaier diagram.

15. Electron emission at the surface of platinum through which hydrogen is passing. L. T. JONES AND VICTOR DURAN, University of California.—When hydrogen is passing through the walls of a hot platinum tube there is an emission of electrons from the exit surface which far exceeds the Richardson emission for platinum for that temperature. The emission as a function of the voltage removing the electrons exhibits the usual saturation but at very low plate voltages apparently differs from the pure thermionic emission. The phenomenon is complicated by the surface effect examined by H. A. Wilson. Attempts to find electron emission at the exit surface of hydrogen passed electrolytically through platinum and iron have thus far been futile. When hydrogen is admitted to a platinum tube which has been glowing for

several hours in vacuum (no emission) electron emission rises to a sharp peak and drops almost as sharply to a constant value. The time of appearance of the peak and its magnitude are both defendent on the previous history of the platinum.

16. The crystal structure of potassium dithionate. M. L. HUGGINS AND GLENN FRANK, Stanford University.—Using x-ray spectra from rotating crystals, the following results have been obtained for $K_2S_2O_6$: The space group is D_3^1 ($3D$-1) of the hexagonal system. The unit of structure has the dimensions $a_0 = 9.8$ and contains 6 K, 6 S and 18 O atoms. The S atoms are in pairs on the three-fold symmetry axes, each S having three O atoms symmetrically placed around it.

17. Refractive indices of calcite in the wave-length range of two to six Angtrom units. ELMER DERSHEM, University of California.—The indices of refraction of calcite in this region must be known for a precise determination of x-ray wave-lengths by reflection from this crystal and it also desirable to determine what type of anomalous dispersion, if any, occurs near the K absorption limit of calcium. A narrow beam of general radiation rendered nearly monochromatic by reflection from a gypsum crystal was reflected from a polished surface of calcite and the critical angle of total reflection determined. It was found that at 1.98 Angstrom units $1-\mu = 17.8\times10^{-6}$ and at 6.00 Angstrom units $1-\mu = 137\times10^{-6}$. These values are in excellent agreement with those calculated from the Drude-Lorentz dispersion formula. This is true of other points on the curve except those within two or three tenths Angstrom unit of the calcium absorption limit. In this region the values of $1-\mu$ are depressed on both sides of the absorption edge, being thus in agreement with the quantum theories of x-ray dispersion of Kronig (Jour. Optical Soc. **12**, 547, 1926) and Kallman and Mark (Ann. d. Physik **82**, 585, 1927).

18. An experimental study of the relative intensities of x-ray lines in the L-spectrum of uranium. SAMUEL K. ALLISON, University of California at Berkeley.—The results so far obtained in this investigation, not yet entirely completed, confirm in general the results already published for thorium (Phys. Rev. **30**, 245, 1927) The present work is being done at 55 kilovolts, in order to work in a region in which the exciting voltage is as far above the critical excitation voltages of the L-series as possible. From previous work, notably that of Jönsson (Zs. f. Phys. **41**, 801, 1927) it is known that the relative intensities of the lines $\gamma_3\gamma_2$, $\beta_3\beta_4$ are not 2:1 as demanded by the extension of the Burger-Dorgelo rules to x-ray spectra. In the second order spectrum in uranium it has been possible to investigate the lines β_3, β_4 free from interfering lines and they are found to be of almost equal intensity. This seems also to be true of γ_3, γ_2 although the evidence here is not so conclusive. A further interesting fact is that the lines γ_4, γ_5, which are present in the tungsten L-spectrum are absent in the thorium and uranium L-spectra. The fact that the lines β_3, β_4 are much weaker relative to β_1 in the thorium spectrum than in tungsten has been confirmed in the uranium spectrum.

19. Infra-red absorption by the S-H bond. JOSEPH W. ELLIS, University of California at Los Angeles. The near infra-red absorption spectra have been recorded for ethyl, n-propyl, n-butyl, iso-amyl, phenyl (thiophenol) and benzyl mercaptans and their corresponding sulfides. This study was undertaken to test an assumption that absorption near 2μ in the spectra of the mercaptans should be modified by the presence of the single S-H linkage. An absorption band was readily found at 2.00μ for thiophenol and benzyl mercaptan, and, although less easily measurable, is detected near that wave-length value in the records of the alkyl mercaptans. The band does not appear with the sulfides. It is regarded as the first harmonic of a band found by Bell (Ber. der Deutsch. Chem. Gesell. **60**, 1749, 1927) at 3.8μ, and is assumed to arise from non-harmonic oscillations in the S-H bond. The sulfur-hydrogen linkage thus seems to behave optically similarly to the carbon-hydrogen and the nitrogen-hydrogen linkages. (See previous abstracts.)

20. Infra-red emission of hydrogen. E. D. MCALISTER, University of California.—Thermocouple observations of emission from a long hydrogen tube of the Wood type indicate

a shift of intensity as a function of pressure. A relative intensity of P_α to H_β of 4 to 1 is observed at a pressure of 1 mm (Hg) of H as compared with 11 to 1 at a pressure of 1/4 mm (Hg) of H. This has an important bearing upon the nature of resonance excitation, since the two lines differ only in final state as to total quantum number. Under this condition of low pressure and with high dispersion the third member of the Brackett series was observed.

21. Vibration spectra of simple hydrocarbons. F. S. BRACKETT, University of California.—The vibration spectra in the region 0.8 to 2.6μ of liquid hydrocarbons obtained with an effective slit width of 30 A° indicate clear cut differentiation between successive members of the paraffine series. Higher resolving power makes possible the identification of distinct vibration frequencies with the different types of H-C bonds. The spectrum of benzene supports the prevalent hypothesis that little distinction exists between its several H-C bonds. Furthermore the types of H-C bonds present in benzene are distinctly different from those exhibited in the paraffine series.

22. Intensity measurements in the multiplets of TiI. GEORGE R. HARRISON, Stanford University.—A 10 meter 15,000 line grating has been mounted for photometric measurements in complex spectra so that up to seven plates can be exposed in various parts of the spectrum from 2000 to 7000A. at once. Measurements are being made on the intensities of lines in multiplets, and on the relative intensities of the multiplets in the triads and pentads of the elements of the iron group. Results obtained in TiI indicate that the well-known intensity formulas are obeyed almost exactly by most lines of all multiplets measured, but that most multiplets contain some lines which depart from both sum and intensity rules. As examples: In the transition $3d^2.4s^2-3d^2.4s.4p$ (Russell, Astrophys. Jour., **66**, 184, 1927) $a^3P'-b^3S'$ and $a^3P'-c^3P$ obey the rules exactly, while $a^3F'-b^3F$ has two lines 100% and 50% too strong, and $a^3F'-b^3D'$ has two 62% and 40% too strong, and one 25% weak. For $3d^3.4s-3d^3.4p$, $a^5F'-b^5G'$ has its main line 36% strong, $a^5F'-c^5D'$ contains two lines 20% low and two 10% low. For $3d^2.4s^2-3d^2.5p$, $a^3F'-b^3G'$ is normal while $a^3F'-b^3F$ has two lines 50% too strong. Frerichs (Ann. der Phys. **81**, 807, 1926) had previously measured two of these multiplets with similar results.

23. Nature of the molecular binding and other properties of the hydrogen halides. R. T. BIRGE and O. R. WULF, University of California.—In order better to study the properties of certain molecules, comprehensive energy level diagrams have been devised which include the various intermediate products occurring in cyclic processes such as used by Born and others. Using some recent improved data, such diagrams have been plotted to scale for HCl, HBr, HI, and (less completely) HF. Levels are given for the neutral molecule with atomic binding and with (hypothetical) ionic binding, as ionized, and as dissociated into various products. Several additional reasons are deduced for believing, with Franck and Kuhn, that these substances exist with *atomic* binding in the non-vibrational state. In particular this conclusion results from a critical study of their infra-red band absorption, and the heats of dissociation derived by linear extrapolation of the vibrational frequency curve. The actual form of this curve seems however to indicate a dissociation into *ions*, an assumption which the wave mechanics appears to show is not necessarily inconsistent with the preceding. The heat of dissociation of these molecules in the ionized state is roughly zero or negative, and this and other significant relations are discussed in connection with known and predicted experimental facts.

24. New data on H_2 absorption. J. J. HAPFIELD, University of California.—The *A-B*, and *A-C* ultra-violet absorption systems of H_2 have been greatly extended. New measurements now include the bands A_0-B_{17}, and A_0-C_{10}. This extension brings both systems near the converging limit, and from these data the heat of dissociation of H_2 with excitation of one of the atoms to the two quantum orbit may be calculated. This limit practically coincides with the beginning of continuous absorption observed by Dieke and Hopfield and interpreted by them as marking this limit. On carrying out the absorption experiments with less hydrogen in the receiver, it was found that this absorption limit is not real and therefore the conclusion

of the above authors concerning the heat of dissociation of H_2 is slightly in error. The new experiments show that the absorption limit merely marks the beginning of what appear to be new and stronger absorption band systems of H_2 probably related to still higher electronic excitation. Furthermore the fact of the absence of a real absorption limit in this case is supported by the distribution of intensity among the A-B, and A-C systems. These bands reach their maximum intensity at about the A_0-B_5 and A_0-C_2 bands respectively and become fainter for higher members instead of stronger.

25. Band spectra in the extreme ultra-violet excited by active nitrogen. HAROLD P. KNAUSS, University of California.—A vacuum grating spectrograph was used to observe spectra between λ2500 and λ1000 excited in certain gases in active nitrogen. CO bands were observed originating in a set of vibrational levels (1–6) of electronic level A, with energies from 8.2 to 9.0 volts. NO bands were found to include, beyond the β and γ bands, a progression belonging to another system, with final levels belonging to the normal electronic state of the molecule. The initial level, identified as an electronic state with zero vibration from Leifson's absorption data, is designated as level C, and the bands are called the δ bands of NO. The O-O band is at λ1915.7, and the energy of excitation is 6.44 volts. No trace of the molecular spectrum of hydrogen, requiring 11.1 volts, was found in the afterglow. These results support conclusions reached earlier by R. T. Birge that when atoms of nitrogen combine to form a molecule with 11.4 volts of energy, some of the energy is lost immediately by radiation of the α group bands. The remainder, from 8 to 10 volts, is retained in a semi-metastable configuration, and is the maximum available for the excitation of other bodies in second type collisions.

26. Series spectra of potassium and calcium. I. S. BOWEN, California Institute of Technology.—Several of the strongest extreme ultra-violet lines in the K_{III}, K_{IV}, Ca_{IV}, and Ca_V spectra are given their series designation. In K_{II} several lines are identified in addition to those found by DeBruin. The absolute value of the terms of K_{II} are determined thus fixing the ionization potential at 31.7 volts. 137 lines are classified in Ca_{III} and the term values of the levels involved are calculated. These correspond to an ionization potential of 51.0 volts.

27. Atmospheric or vacuum arc for standard wave-lengths? HAROLD D. BABCOCK, Mount Wilson Observatory.—Unsupported statements in the report of the Optical Society of America (J.O.S.A. *16*, 44, 1928) are controverted by the facts. Typical iron lines from atmospheric and vacuum arcs are shown by photographs to be almost indistinguishable. Equality of errors of setting on these lines is illustrated. Differences from plate to plate, for each of three observers, are found equally great for both arcs. Differences from observer to observer show the same range for both arcs. The present standard arc is as reproducible and as accurately measurable as the vacuum arc. Other features discussed are (1) adaptability to the purpose of producing standards, (2) differences of wave-length between standards and corresponding solar lines, (3) distinction between the study of laboratory spectra from vacuum sources and the practical problem of producing standards of wave-length, (4) pressure displacements for iron lines. New observations, some now in press, will soon make available vacuum iron arc wave-lengths equal in precision to the standards, but not greater. Attempts to discredit the adopted standard arc are without justification. No evidence is found of superiority of the vacuum arc.

28. Astrophysical importance of the rare-earth elements. CHARLES E. ST. JOHN, Mount Wilson Observatory.—Characteristic features: The low values for the rotation of the sun and the high velocities of out flow from spots given by them show that they are at very low level in the sun's atmosphere. They are present in the ionized state, but their spectra are peculiar for ionized atoms in that their lines are generally stronger in the arc than in the spark, and in flash spectra show marked differences from both the ionized and neutral atoms of other elements. Their lines are greatly enhanced in the spectra of γ Cygni but are weakened in the spectra of sun-spots. Presence in sun and stars: Nine earth-elements are recognized in the sun: namely La^+, Ce^+, Pr^+, Nd^+, Sa^+, Eu^+, Gd^+, Dy^+, and Yb^+. The first seven are found

also in γ Cygni. Laboratory data deficient: Accurate measurement of the wave-lengths and study of the relative intensities and appearance of their lines under varied conditions of excitation offer opportunities for laboratory investigations not only of value because of their physical and theoretical importance, but also of interest because of questions of technique and the possibility of solving problems peculiar to this group of elements. Such investigations are within the compass of many laboratories.

29. An improved grating for the extreme infra-red. RICHARD M. BADGER, California Institute of Technology.—A reflection grating has been constructed, consisting of a plate of glass on which is deposited photographically a series of narrow gelatin laminae. These are equally spaced and their width is equal to that of the blank glass spaces between. The even order spectra are absent, and certain wave-lengths, depending on the thickness of the laminae, are absent in the zero order, being concentrated almost entirely in the first order. For these wave-lengths this grating compares favorably with an echlette. The intensity is not quite as great but higher orders are missing, or are weak, and the symmetrical form is very desirable when making absolute wave-length measurements. With such a grating, of 1 mm spacing, the ammonia rotation spectrum has been resolved and six lines measured between 56 and 127μ.

SUPPLEMENTARY PROGRAM

30. The rotational and vibrational energy of molecules. RAYMOND T. BIRGE, University of California.—A literal interpretation of the new wave mechanics indicates that the quantities ω_0, B_0, D_0, etc. of the old mechanics refer, not to a non-vibrating molecule, but to one with a half unit of vibrational energy ($n=1/2$). Hence the theoretical relation $D_0=-4B_0^3/\omega_0^2$ is not necessarily true, using the old mechanics values. From Kemble's theoretical equations, explicit expressions are obtained for the percentage change of each side of this equation, in passing from the new to the old mechanics, and these are applied to a number of molecules for which reliable data are available. In all cases the differential change in the two sides is less than the probable experimental errors, thus accounting for the observed verification of the equation in the old mechanics. With more accurate data it however is a potential means of verifying the above literal interpretation of the new mechanics, originally suggested by the observed electronic isotope effect in BO. Other relations between the constants of band spectra and those of the molecular potential function are discussed and numerically tested on various molecules; in particular, Richardson's indirect method for evaluating the moment of inertia of H_2.

31. Tables of constants for diatomic molecules, derived from band spectra data. RAYMOND T. BIRGE, University of California.—A new table of constants has been prepared, similar to that on pages 230–232 of "Molecular Spectra in Gases," using data available to Nov. 1927. The nature of the electronic transition (such as $^2P-^2S$) is given where known. About twice as many systems are listed as in the older table, and the constants are accompanied by critical remarks as to their source and reliability. *All* numerical values are stated in terms of the *old* quantum mechanics, but transformation equations to the new mechanics are given and discussed. Two additional tables have been prepared. The first gives in order of energy the electronic levels and correlated constants (ω_0, I_0 etc.) of the molecules BO, CO, CO^+, H_2, He_2, N_2 and NO. The other lists heats of dissociation of diatomic molecules, derived from band spectra.